MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 2, 2019/2020

BEF3014 –ECONOMETRICS MODELLING AND FORECASTING

(All sections/ Groups)

5 MARCH 2020
2.30 p.m. - 4.30 p.m.
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This Question paper consists of **ELEVEN** pages with **FOUR** questions only.
2. Attempt **ALL FOUR** questions. The distribution of the marks for each question is given.
3. Please write all your answers in the Answer Booklet provided.
4. Statistical tables and formulas are attached.

QUESTION 1 (25 marks)

(a) Define each of the components of the classic time-series multiplicative decomposition method and explain how they are determined. (12 marks)

(b) Write the expressions for the following models:
(i) MA(3) (2 marks)
(ii) ARMA(1,2) (2 marks)
(iii) ARIMA(2,1,2) (2 marks)

(c) Why is it important to test for non-stationarity in time series data before attempting to build an empirical model? Explain. (7 marks)

QUESTION 2 (25 marks)

(a) **Table 1** shows the inventory pattern and sales volume that have been observed in the ABC Corporation over 11 years:

Table 1

Year	Inventory	Sales volume
2007	2	5
2008	3	6
2009	5	6
2010	4	5
2011	3	5
2012	5	7
2013	7	6
2014	6	6
2015	7	7
2016	8	7
2017		8

(i) Find the forecast values of the inventory from 2007 to 2016 by using single exponential smoothing (SES) with a smoothing constant of 0.3 and an initial value of 2. (2 marks)

Continued...

(ii) By regressing Inventory (Y) on Sales Volume, the following regression result is obtained:

$$\widehat{Inventory}_t = -6.0000 + 1.8333 * Sales\ Volume \quad \ldots (2.1)$$

Find the forecast values of the inventory from 2007 to 2016 by using the regression result obtained. (3 marks)

(iii) Evaluate these forecasting methods (from parts (i) to (ii)) using Mean Square Error (MSE) and Mean Absolute Percentage Error (MAPE). Show all calculations. (8 marks)

(iv) Based on your answer in part (iii), forecast the inventory for year 2017 using the best technique. (2 marks)

(b) A parking zone located in a major shopping centre near the KL city has the following history of customers (in hundreds) from year 2013 to 2016:

Table 2

Period	Y	MA4	CMA	Seasonal Factors	S	T	Yhat
2013Q1	5.4					4.7	
2013Q2	7					5.0	
2013Q3	3	4.4	4.49	0.6685		5.2	
2013Q4	2	4.6	4.88	0.4103		5.5	
2014Q1	6.5	5.1	5.38	1.2093		5.7	
2014Q2	9	5.6	5.75	1.5652		6.0	
2014Q3	5	5.9	6.10	0.8197		6.2	
2014Q4	3	6.3	6.58	0.4563		6.5	
2015Q1	8.3	6.8	6.95	1.1942		6.7	
2015Q2	11	7.1	7.20	1.5278		6.9	
2015Q3	6	7.3	7.54	0.7960		7.2	
2015Q4	4	7.8	8.00	0.5000		7.4	
2016Q1	10	8.3	8.38	1.1940		7.7	
2016Q2	13	8.5	8.63	1.5072		7.9	
2016Q3	7	8.8				8.2	
2016Q4	5					8.4	
2017Q1							
2017Q2							
2017Q3							
2017Q4							

Continued...

(i) Using the multiplicative model, determine the seasonal index (S) for each quarter. (4 marks)

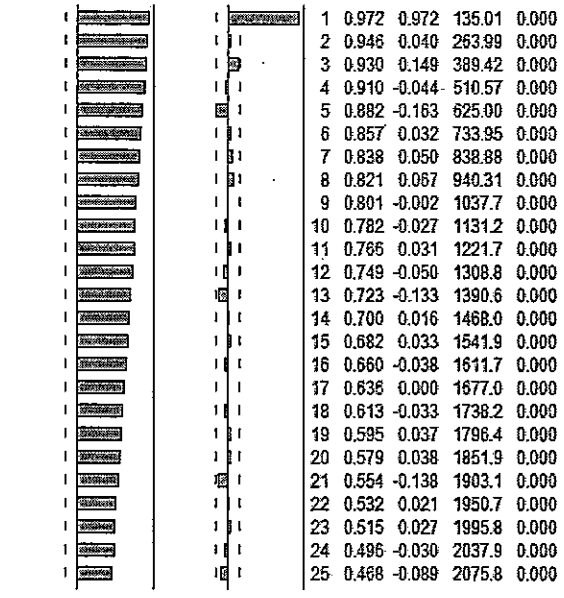
(ii) Using the multiplicative model, make a forecast for each quarter of year 2017 [Hint: Given the fitted trend line is 4.49 + 0.2453**Time*, while the cyclical index and irregular component are both set to the value of 1.0]. (4 marks)

(iii) The actual numbers of customers (in hundreds) served per quarter in year 2017 were 11, 13, 8, and 6 for quarters 1 through 4, respectively. Calculate the Root Mean Square Error (RMSE) for year 2017. (2 marks)

QUESTION 3 (25 marks)

(a) The Sample Correlograms (up to 25 lags) for the time series Money Supply (*M2*) and Gross Domestic Product (*GDP*) are shown as below:

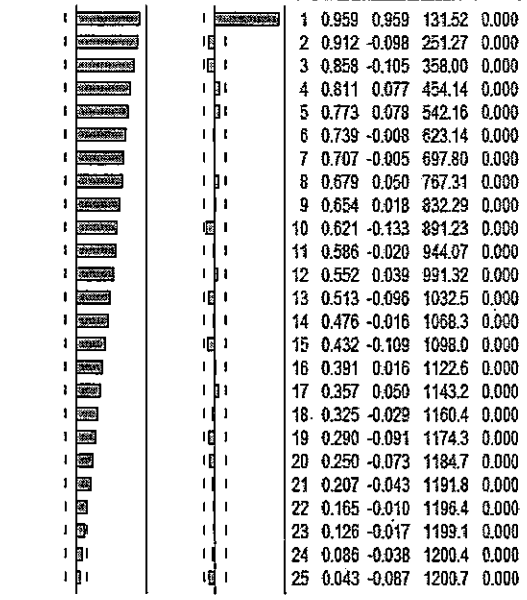
Sample: 1971Q1 2005Q4
Included observations: 140



Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.972	0.972	135.01	0.000
		2	0.946	0.040	263.99	0.000
		3	0.930	0.149	389.42	0.000
		4	0.910	-0.044	510.57	0.000
		5	0.882	-0.163	625.00	0.000
		6	0.857	0.032	733.95	0.000
		7	0.838	0.050	838.88	0.000
		8	0.821	0.067	940.31	0.000
		9	0.801	-0.002	1037.7	0.000
		10	0.782	-0.027	1131.2	0.000
		11	0.766	0.031	1221.7	0.000
		12	0.749	-0.050	1308.8	0.000
		13	0.723	-0.133	1390.6	0.000
		14	0.700	0.016	1468.0	0.000
		15	0.682	0.033	1541.9	0.000
		16	0.660	-0.038	1611.7	0.000
		17	0.636	0.000	1677.0	0.000
		18	0.613	-0.033	1738.2	0.000
		19	0.595	0.037	1796.4	0.000
		20	0.579	0.038	1851.9	0.000
		21	0.554	-0.138	1903.1	0.000
		22	0.532	0.021	1950.7	0.000
		23	0.515	0.027	1995.8	0.000
		24	0.496	-0.030	2037.9	0.000
		25	0.468	-0.089	2075.8	0.000

Figure 3.1 *M2*

Sample: 1971Q1 2005Q4
Included observations: 140



Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.959	0.959	131.52	0.000
		2	0.912	-0.098	251.27	0.000
		3	0.858	-0.105	358.00	0.000
		4	0.811	0.077	454.14	0.000
		5	0.773	0.078	542.16	0.000
		6	0.739	-0.008	623.14	0.000
		7	0.707	-0.005	697.80	0.000
		8	0.679	0.050	767.31	0.000
		9	0.654	0.018	832.29	0.000
		10	0.621	-0.133	891.23	0.000
		11	0.586	-0.020	944.07	0.000
		12	0.552	0.039	991.32	0.000
		13	0.513	-0.096	1032.5	0.000
		14	0.476	-0.016	1068.3	0.000
		15	0.432	-0.109	1098.0	0.000
		16	0.391	0.016	1122.6	0.000
		17	0.357	0.050	1143.2	0.000
		18	0.325	-0.029	1160.4	0.000
		19	0.290	-0.091	1174.3	0.000
		20	0.250	-0.073	1184.7	0.000
		21	0.207	-0.043	1191.8	0.000
		22	0.165	-0.010	1196.4	0.000
		23	0.126	-0.017	1199.1	0.000
		24	0.086	-0.038	1200.4	0.000
		25	0.043	-0.087	1200.7	0.000

Figure 3.2 *GDP*

What general pattern do you see? Intuitively, which one(s) of these time series seem to be stationary? Explain your answer statistically. (5 marks)

Continued...

(b) The Augmented Dickey-Fuller (ADF) test results for the two time series (*M2* and *GDP*) are as below:

$$\Delta M2_t = 312.55 - 0.20M2_{t-1} - 0.63\Delta M2_{t-1} - 0.64\Delta M2_{t-2} \quad \ldots (3.1)$$
$$\tau \qquad (1.55) \quad (-2.13) \quad (-6.11) \qquad (-7.17)$$
$$R^2 = 0.53$$

$$\Delta^2 M2_t = 35.58 - 3.11\Delta M2_{t-1} + 1.33\Delta^2 M2_{t-1} - 0.59\Delta^2 M2_{t-2} \quad \ldots (3.2)$$
$$\tau \qquad (0.23) \quad (-16.86) \quad (10.13) \qquad (-7.85)$$
$$R^2 = 0.81$$

$$\Delta GDP_t = -734.04 - 0.03GDP_{t-1} - 0.15\Delta GDP_{t-1} + 14.57Trend \quad \ldots (3.3)$$
$$\tau \qquad (-1.35) \quad (-0.97) \quad (-1.62) \qquad (1.89)$$
$$R^2 = 0.06$$

$$\Delta^2 GDP_t = -482.13 - 1.09\Delta GDP_{t-1} - 0.07\Delta^2 GDP_{t-1} + 9.05Trend \quad \ldots (3.4)$$
$$\tau \qquad (-0.99) \quad (-7.40) \quad (-0.78) \qquad (1.62)$$
$$R^2 = 0.60$$

where *M2* = money supply, *GDP* = gross domestic product, Δ = first-difference operator and Δ^2 = second-difference operator.

The critical τ values (at 10%) are –2.57 and –3.16 for models without trend and with trend, respectively.

From the unit root tests,

(i) Is M2 integrated of order zero I(0), order one I(1) or order two I(2)? Explain. (3 marks)

(ii) Is GDP integrated of order zero I(0), order one I(1) or order two I(2)? Explain. (3 marks)

Continued...

(c) Given the graphs of **Figures 3.3 and 3.4** of the sample autocorrelations and the sample partial autocorrelations, tentatively identify an ARIMA model from each pair of the graphs. (6 marks)

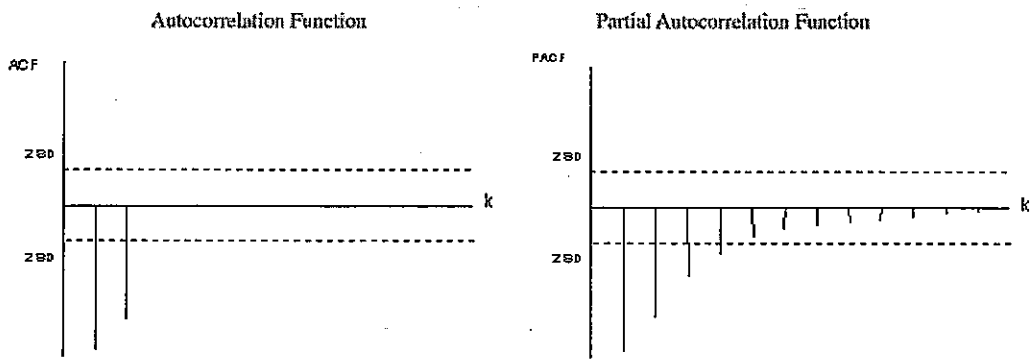


Figure 3.3

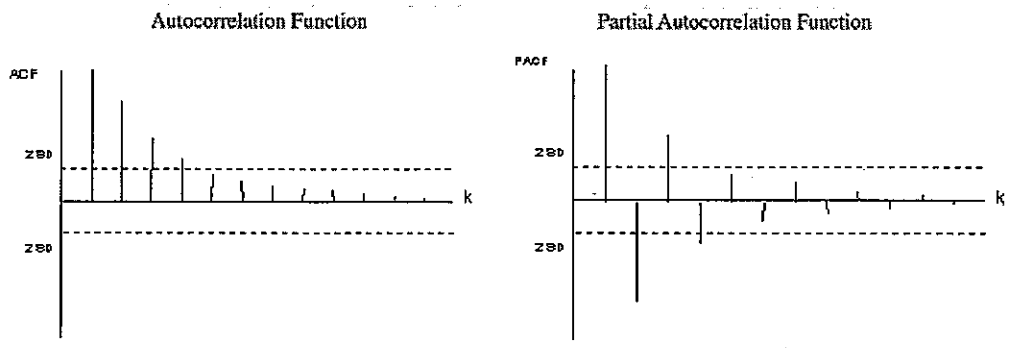


Figure 3.4

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(d) By using yearly data covering the period 1980-2019 for Malaysia, the variance decomposition (VDC) based on five variables: real output (Y), money (M1), interest rate (IR), prices (CPI) and exchange rate (ER), is presented in **Table 3**.

Table 3 Variance Decomposition (Cholesky Decomposition) for M1 model

		Percentage of forecast variance explained by innovation in:				
Yrs	**Relative variance in:**	**ΔY**	**ΔM1**	**ΔIR**	**ΔCPI**	**ΔER**
1	**ΔY**	100.00	0.00	0.00	0.00	0.00
2		85.36	0.01	8.37	1.22	5.03
3		83.33	0.43	9.19	1.83	5.22
4		82.51	0.41	8.53	1.71	6.84
5		83.14	0.38	8.04	1.60	6.83
10		82.53	0.40	8.68	1.47	6.92
1	**ΔM1**	34.26	65.74	0.00	0.00	0.00
2		40.97	38.99	17.70	2.19	0.13
3		47.05	29.94	17.57	2.02	3.41
4		56.19	21.66	14.64	1.58	5.93
5		62.04	17.15	13.17	1.26	6.38
10		69.31	10.15	12.54	0.80	7.19
1	**ΔIR**	0.67	5.99	93.34	0.00	0.00
2		43.99	3.03	35.91	0.31	16.77
3		65.80	1.48	18.58	0.26	13.88
4		70.53	1.15	16.38	0.28	11.66
5		71.29	1.08	16.49	0.27	10.88
10		74.74	0.82	14.18	0.20	10.05
1	**ΔCPI**	18.39	0.04	3.94	77.64	0.00
2		15.09	0.11	10.10	73.54	1.16
3		15.03	0.47	9.33	73.21	1.96
4		16.72	0.47	9.16	71.35	2.30
5		18.83	0.47	8.94	69.36	2.41
10		22.46	0.47	9.25	65.05	2.76
1	**ΔER**	0.29	36.80	2.13	0.41	60.36
2		35.22	17.47	12.50	0.63	34.18
3		34.33	16.92	11.96	2.13	34.65
4		37.75	15.51	11.31	2.06	33.36
5		39.06	15.19	11.09	2.03	32.64
10		39.46	14.93	11.33	2.02	32.27

Investigate which variable has relative importance in explaining the money (M1) in Malaysia. Support your answer with figures from **Table 3**. (8 marks)

Continued...

QUESTION 4 (25 marks)

(a) Using annual data over a nine-year period, the following simple bivariate linear regression model was estimated to explain a firm's sales revenue from the perspective of the income of its customer's (*INC*):

$$Sales\ Revenue = 81.38 + 0.23*INC \quad \ldots (4.1)$$
$$(0.018)$$

where the standard error of the slope estimate is reported in parentheses.

(i) Interpret the values of the terms of intercept and slope in the fitted regression equation. (4 marks)

(ii) What level of sales would you forecast if the income was $4,200? (3 marks)

(b) Analysing the monthly observations on the returns to the country A share price index for the period 2005:01 to 2019:12, you obtained a plot of the returns as shown in **Figure 4.1**, together with its histogram in **Figure 4.2**.

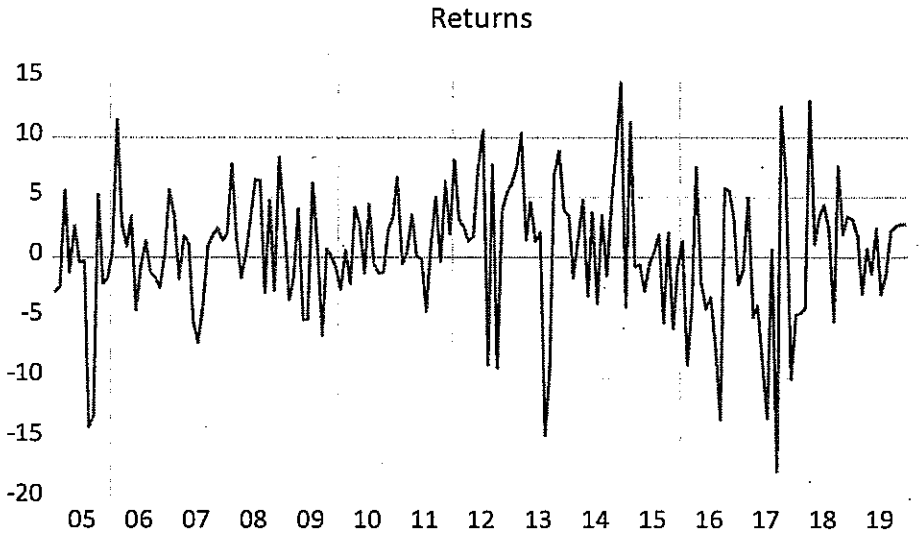

Figure 4.1 Returns to Country A share price index

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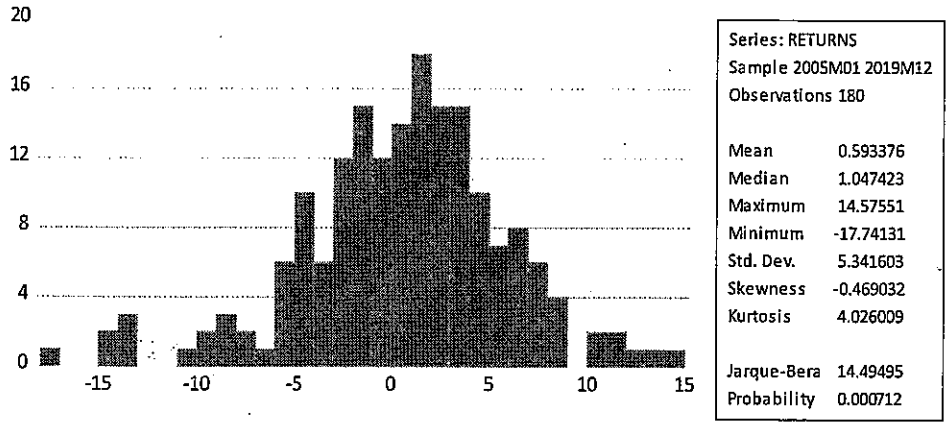

Figure 4.2 Histogram of returns

(i) What do you notice about the volatility of the returns? Identify the periods of big changes and the periods of small changes. (4 marks)

(ii) Is the distribution of returns normal? Is this the unconditional or conditional distribution? (7 marks)

(iii) Estimate an ARCH(1) model and check that you obtain the following results:

$$\begin{matrix} \hat{r}_t = 0.639 & \hat{h}_t = 21.464 + 0.245\hat{e}_{t-1}^2 \\ (t) \quad (2.383) & (10.108) \quad (2.106) \end{matrix} \quad \ldots (4.2)$$

Interpret the results. (3 marks)

(iv) A plot of the conditional variance is shown in **Figure 4.3**. Do the periods of high and low conditional variance coincide with the periods of big and small changes in returns? Explain. (4 marks)

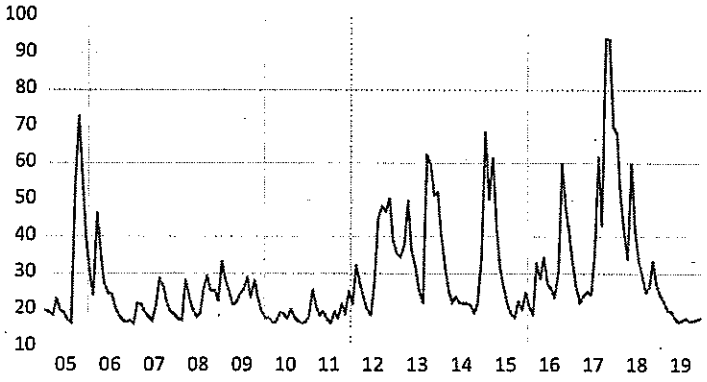

Figure 4.3 Estimated conditional variance, $\hat{h}_t$

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Statistical Tables

Appendix 1: t-Table

two tails	0.2	0.1	0.05	0.02	0.01
One tail	0.1	0.05	0.025	0.01	0.005
df					
10	1.37	1.81	2.23	2.76	3.17
20	1.33	1.72	2.09	2.53	2.84
30	1.31	1.70	2.04	2.46	2.75
40	1.30	1.68	2.02	2.42	2.70
50	1.30	1.68	2.01	2.40	2.68
60	1.30	1.67	2.00	2.39	2.66
75	1.29	1.67	1.99	2.38	2.64
100	1.29	1.66	1.98	2.36	2.63
120	1.29	1.66	1.98	2.36	2.62
200	1.29	1.66	1.98	2.36	2.62

Appendix 2: Durbin Watson d Table

Critical Values for the Durbin-Watson Statistic (d)

Level of Significance $\alpha = 0.05$

n	$k=1$		$k=2$		$k=3$		$k=4$		$k=5$	
	d_L	d_U	d_L	d_U	d_L	d_U	d_L	d_U	d_L	d_U
10	0.88	1.32	0.70	1.64	0.53	2.02	0.38	2.41	0.24	2.82
15	1.08	1.36	0.95	1.54	0.82	1.75	0.69	1.97	0.56	2.21
20	1.20	1.41	1.10	1.54	1.00	1.68	0.90	1.83	0.79	1.99
25	1.29	1.41	1.21	1.55	1.12	1.66	1.04	1.77	0.95	1.89
30	1.35	1.49	1.28	1.57	1.21	1.65	1.14	1.74	1.07	1.83
40	1.44	1.54	1.39	1.60	1.34	1.66	1.29	1.72	1.23	1.79
50	1.50	1.59	1.46	1.63	1.42	1.67	1.38	1.72	1.34	1.77
60	1.55	1.62	1.51	1.65	1.48	1.69	1.44	1.73	1.41	1.77
70	1.58	1.64	1.55	1.67	1.52	1.70	1.49	1.74	1.46	1.77
80	1.61	1.66	1.59	1.69	1.56	1.72	1.53	1.74	1.51	1.77
90	1.63	1.68	1.61	1.70	1.59	1.73	1.57	1.75	1.54	1.78
100	1.65	1.69	1.63	1.72	1.61	1.74	1.59	1.76	1.57	1.78
150	1.72	1.75	1.71	1.76	1.69	1.77	1.68	1.79	1.66	1.80
200	1.76	1.78	1.75	1.79	1.74	1.80	1.73	1.81	1.72	1.82

where n = number of observations and k = number of independent variables, excluding the intercept.

Formulas

Error, $\varepsilon_t = y_t - \hat{y}_t$

Mean Absolute Error, $MAE = \frac{1}{n}\sum_{t=1}^{n}|\varepsilon_t|$

Mean Squared Error, $MSE = \frac{1}{n}\sum_{t=1}^{n}\varepsilon_t^2$

Root Mean Squared Error, $RMSE = \sqrt{MSE}$

Mean Absolute Percentage Error,

$$MAPE = \frac{1}{n}\sum_{t=1}^{n}|PE_t| = \frac{1}{n}\sum_{t=1}^{n}\left|\left(\frac{\varepsilon_t}{y_t}\right)x100\right|$$

Mean Percentage Error,

$$MPE = \frac{1}{n}\sum_{t=1}^{n}PE_t = \frac{1}{n}\sum_{t=1}^{n}\left(\frac{\varepsilon_t}{y_t}\right)x100$$

Theil's U-statistics, $U = \sqrt{\frac{\sum_{t=1}^{n}\varepsilon_t^2}{\sum_{t=1}^{n}(y_t - y_{t-1})^2}}$

Naïve model, $\hat{Y}_{t+1} = Y_t$

Naïve trend model,
$\hat{Y}_{t+1} = Y_t + (Y_t - Y_{t-1})$

Naïve rate of change model,
$\hat{Y}_{t+1} = Y_t * \frac{Y_t}{Y_{t-1}}$

Naïve seasonal model for quarterly data,
$\hat{Y}_{t+1} = Y_{t-3}$

Naïve trend and seasonal model for quarterly data, $\hat{Y}_{t+1} = Y_{t-3} + \frac{(Y_t - Y_{t-4})}{4}$

Simple average model, $\hat{Y}_{t+1} = \frac{1}{t}\sum_{i=1}^{t}Y_t$

Moving average model for k time periods,
$\hat{Y}_{t+1} = \frac{Y_t + Y_{t-1} + ... + Y_{t-k+1}}{k}$

Double moving average,

$$M_t = \hat{Y}_{t+1} = \frac{Y_t + Y_{t-1} + ... + Y_{t-k+1}}{k}$$

$$M_t' = \frac{M_t + M_{t-1} + M_{t-2} + ... + M_{t-k+1}}{k}$$

$$a_t = M_t + (M_t - M_t') = 2M_t - M_t'$$

$$b_t = \frac{2}{k-1}(M_t - M_t')$$

$$\hat{Y}_{t+p} = a_t + b_t p$$

Simple exponential smoothing,
$\hat{Y}_{t+1} = \alpha Y_t + (1-\alpha)\hat{Y}_t$

Holt's linear smoothing

The exponentially smoothed series, or current level estimate,
$L_t = \alpha Y_t + (1-\alpha)(L_{t-1} + T_{t-1})$

The trend estimate,
$T_t = \beta(L_t - L_{t-1}) + (1-\beta)T_{t-1}$

Forecast p periods into the future,
$\hat{Y}_{t+p} = L_t + pT_t$

Holt-Winter's multiplicative smoothing

The exponentially smoothed series or level estimate,

$$L_t = \alpha \frac{y_t}{S_{t-s}} + (1-\alpha)(L_{t-1} + T_{t-1})$$

The trend estimate,

$$T_t = \beta(L_t - L_{t-1}) + (1-\beta)T_{t-1}$$

The seasonality estimate,

$$S_t = \gamma \frac{y_t}{L_t} + (1-\gamma)S_{t-s}$$

Forecast p periods into the future,

$$\hat{Y}_{t+p} = (L_t + pT_t)S_{t-s+p}$$

Time additive decomposition,

$$Y_t = S_t + T_t + C_t + I_t$$

Time series multiplicative decomposition,

$$Y_t = S_t * T_t * C_t * I_t$$

AR process: p-order autoregressive model

$$y_t = \gamma_0 + \gamma_1 y_{t-1} + \gamma_2 y_{t-2} + \ldots + \gamma_p y_{t-p} + \varepsilon_t$$

MA process: q-order moving average model

$$y_t = \mu_t + \varepsilon_t - \theta_1 \varepsilon_{t-1} - \theta_2 \varepsilon_{t-2} - \ldots - \theta_q \varepsilon_{t-q}$$

Regression model:

$$\text{t - statistic} = \frac{\hat{\beta} - \beta}{\text{se}(\hat{\beta})}$$